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PRIME NUCLEAR AIRLIFT FORCE (PNAF) MISSIONS INVOLVING THE USE OF C-130 AND C-141 AIRCRAFT

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(9) Final Report

DIRECTORATE OF NUCLEAR SURETY
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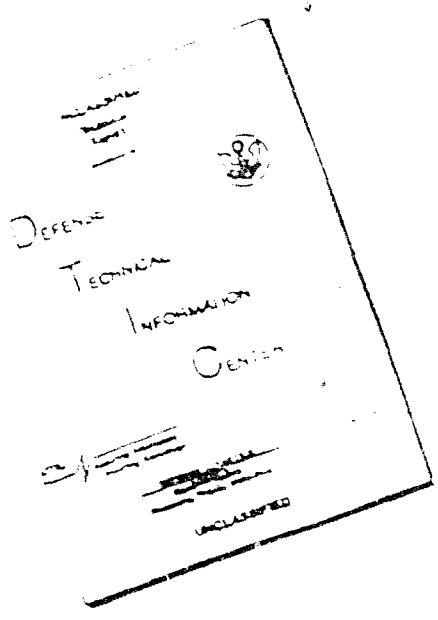

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This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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Director of Nuclear Surety

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This report estimates the accident rate for C-130 and C-141 aircraft while involved in the air transportation of nuclear weapons as cargo. Causes and factors involved in accidents are shown, and beneficial practices are identified.

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INTRODUCTION

This is a study of the safety aspects of transporting nuclear weapons by military cargo aircraft. The safety history of nuclear cargo airlifts and other related operations was used to predict the expected frequency of accidents. Several kinds of accidents could have been chosen as a basis for the study. The basis chosen was that of a "Broken Arrow" accident.

A Broken Arrow is defined as an accident or unexpected event involving a nuclear weapon that results in any of the following consequences: nuclear detonation; nonnuclear detonation or burning; loss, theft, seizure, or destruction; radioactive contamination; actual or perceived public hazard. Some elements of this definition describe events that are much more likely to happen than others. The most likely is "perceived public hazard." This is judged to correspond to any accident in which an aircraft carrying a nuclear weapon is destroyed or irreparably damaged.

Occurrences of "actual public hazard" are much less likely to occur. Studies by Sandia National Laboratories[1,2] attempt to statistically describe accident environments and the response of classes of nuclear weapons that could be involved in those accidents. This approach gives probability numbers for the occurrence of accidents defined in terms of what actually happens to the weapons. Other studies[3] incorporate damage models that attempt the next step of finding the probability of occurrence of accidents defined in terms of what ultimately happens to people and property.

There is considerable uncertainty in each of these steps, especially when the accident is defined in terms of consequences to people and property. These uncertainties arise because the data consist of small or ambiguous samples. The justification for "one more study" must ultimately rest on the reduction of some of this uncertainty and therefore on data. This study is based on a large body of accident reports that were carefully screened to obtain a

consistent set applicable to nuclear airlift operations. The data is presented in tabular form in the report, and individual summaries of the accidents are in a separate appendix.

OBJECTIVES

Determine the expected frequency of occurrence of accidents to cargo aircraft transporting nuclear weapons that would result in destruction of or irreparable damage to the aircraft.

Identify factors contributing to the accident rate that can be changed by improvements to the system.

DISCUSSION

The study objectives require determination of an accident rate for C-130 and C-141 aircraft. The rate needed is destroyed aircraft per amount of flying exposure. We will primarily use a "departure" as a unit of flying exposure, where a departure is one takeoff (followed ultimately by landing and including all between). The preference for departures, instead of miles or hours of flight, is because the accident data show a very low incidence of accidents in cruise flight. Also, to keep the magnitude of the numbers near one, the rate will usually be expressed as destroyed aircraft per million departures.

If nuclear weapons were carried as routine cargo on a representative sample of all kinds of C-141 and C-130 missions, a very direct analytical approach would suffice. Assuming a similarity between the operational conditions of the recent past and of the near future, one could use the observed accident rate to predict the future accident rate by statistical means.

PNAF operations are not strictly typical of all C-141 operations or of all C-130 operations. But, despite the differences that exist, the direct approach could still be used if the historical rate used was PNAF destroyed aircraft per million PNAF departures. This historical rate for both the C-130 and C-141 is zero; however, we will show that this fact permits little precision

in the analysis since it would almost always be observed. That is, we will later show that the C-141 has an accident rate of about three and one-half destroyed aircraft per million departures and the PNAF C-141 rate is of the order of one per million departures. The whole history of C-141 PNAF flying is of the order of 10,000 departures. Therefore, assuming the Poisson distribution applies, out of a large number of samples each of 10,000 C-141 departures one would expect to find zero destroyed aircraft accidents in any given sample about 96% of the time. Even though we have accurate data on PNAF accidents (zero of them) and on PNAF departures for both C-141 and C-130 operations, we cannot precisely predict accident rates by direct methods because the historical sample is too small.

An indirect method of predicting the PNAF accident rates is to use the larger sample of historical data, representing all C-141 operations and all C-130 operations. This data could be used directly if there were no differences between PNAF flights and typical flights. However, differences are known to exist and their influence must be allowed for.

A significant area of difference is that the overall history will include many different types of operations, and some of these may be of a class having a very different accident rate from PNAF operations. An example would be combat airlift operations. This atypical class must be excluded from the data base by deleting the accidents and the departures attributable to the excluded operations. The remaining data would be a large historical sample of all operations having approximately the same intrinsic hazards as PNAF operations.

Another source of differences is that factors influencing accident rates may be present in actual PNAF operations to a different degree than they are present in the larger "all operations similar to PNAF" sample. These factors are grouped in this study as factors involving crew selection and training, factors involving maintenance, and factors involving conditions of flight.

To make the best possible prediction of accident rate from the "all operations similar to PNAF" sample, the effect of each of these differences must be estimated, and a correction for the effect included. It is worth noting that any exclusions made in going from "all operations" to "all operations similar to PNAF" are aimed at excluding operations having hazards not found in PNAF operations; while corrections made for effects of crew selection, maintenance, and conditions of flight are to account for hazards that are present in PNAF operations but are possibly present to a different degree.

The step in the analysis of excluding from the data base those types of operations having, as a class, a very different accident rate would best be done by examining historical accident rates for all of the various types of operations. Unfortunately, the data base will not permit this. The accident reports are very complete, and one can easily assign an accident occurrence to a given type of operation and then accumulate totals. However, there is no detailed breakdown available on flying exposure by type of operation. Thus, the rates cannot be obtained. The only alternative is to make judgments that certain operations involve hazards not found in PNAF operations and then to exclude accidents occurring during those operations. Having done this, one must then also exclude all of the flying exposure related to those operations. However, we have already said that the data to make that exclusion is not available. The unhappy result is that a poorly supportable estimate is required. In the C-141 data, no accidents that destroyed aircraft are excluded, and we assume all C-141 operations to be "similar to PNAF." In the C-130 data, exclusions are needed for actual combat operations, combat airlift proficiency training, initial crew training including maneuvering related to combat aircraft, low-level search and rescue, and weather reconnaissance typhoon penetrations. The excluded accidents and flying exposure are discussed in the "Data Base" section.

Estimates of the effects of crew selection, maintenance, and conditions of flight to allow adjustments to the accident rate predicted from "all operations similar to PNAF" are obtained by examining a body of accident data concerning commercial aircraft. The comparison involves commercial aircraft generally similar to the C-141. Four important assumptions are made. The first is that the correction, used as a multiplier, that is estimated for obtaining the C-141 PNAF rate from the C-141 "all operations" rate is also applicable to the C-130. Only the C-141 and similar commercial aircraft are actually compared. The comparison is not repeated for the C-130 and large commercial turboprop aircraft. The next two assumptions are that PNAF crew selection results in crew proficiency equal to that found in the commercial flying used for comparison and that, likewise, the PNAF maintenance practices result in equipment reliability equal to that in the comparison commercial flying. The last assumption is that PNAF conditions of flight are less frequently as hazardous as those found in the comparison commercial flying.

Since the comparison commercial flying has a historical accident rate that is over three times better than the corresponding C-141 accident rate, all of these last assumptions tend to project a safer picture of PNAF operations.

The effect of the crew selection assumption and the aircraft maintenance assumption is to say that the PNAF accident rate is better than the "all operations similar to PNAF" rate and, for the C-141, is equal to the comparison commercial flying accident rate. If the reader disagrees with the assumptions, they at least allow rapid mental adjustments to the conclusions. For example, the commercial rate is roughly three times better (lower) than the C-141 "all operations" rate. If one believes that PNAF crew selection and maintenance practices are ineffective, use the C-141 "all operations" rate. If one believes that PNAF crew selection and maintenance practices are very much better than commercial practice, one could estimate a commensurate

further improvement. The assumption made in this study, that of equality, is based primarily on the author's personal perceptions. A check of the reasonability of this assumption was made by providing a draft copy of this study to the Headquarters, Military Airlift Command office in charge of nuclear airlift operations and to some Air Force Reserve C-141 pilots who are also commercial airline pilots. They concurred that the assumption was reasonable. The special PNAF procedures for crew selection and maintenance are established by Military Airlift Command Regulation 55-18, Volume I (C1).[14] The part applicable to crew selection is Chapter 2, paragraphs 2-7 and 2-8. Maintenance is covered in Chapter 8, especially paragraph 8-2, "Aircraft Selection and Preparation."

The assumption that PNAF flying is less frequently as hazardous as the comparison commercial flying has to do with the character of the accident histories for the C-141 and the comparison commercial flying. By the method used to select and tabulate accident data in this report, 40% of the accidents that destroyed commercial aircraft involved weather as a cause or contributing factor. Only 11% of the destroyed C-141 aircraft similarly involved weather. Because of the small number (nine) of destroyed C-141 aircraft, one of which was caused by weather, this apparent difference is not conclusive. However, it is supported by the perception that commercial aircrews are under pressure to adhere to schedules and routinely fly into weather conditions that C-141 aircrews avoid. A National Transportation Safety Board special study[11] reports that 47% of air carrier accidents occur during instrument landing system (ILS) precision approach, indicating a significantly increased hazard during adverse weather landings. PNAF missions especially avoid those conditions since the extra restrictions in their mission planning result in a substantial weather margin built in. The restrictions that are most effective in this respect are over-flight restrictions and selection of alternate/emergency airfields with nuclear airlift support capability. By the time all of the restrictions have

been met, the flight plan is so constrained that, if the destination area weather is marginal, you usually just don't go. Avoiding adverse terminal area weather may further improve the PNAF accident rate by roughly 30%.

DATA BASE

Tabular summaries of all the data used in this study are presented in this section. Most of the source data is organized in a separate appendix because the accident reports are privileged and distribution is limited by AFR 127-4, "Investigating and Reporting U.S. Air Force Mishaps."

While data on several different classifications of aircraft accidents are summarized, the accident class used as a basis of comparison and for conclusions in this study is an accident in which an aircraft is destroyed or irreparably damaged. There have been no such accidents on PNAF flights of either C-141 or C-130 aircraft.

Data on all C-141 flights over the whole history of the aircraft through 1979 are used, in part, to estimate the accident rate for C-141 PNAF flights. Data on all C-130 flights through 1978 are used, in part, to estimate the accident rate for C-130 PNAF flights. Data on certain U.S. air carrier operations are also used. All data on the C-141 and C-130 aircraft were obtained from the Air Force Inspection and Safety Center at Norton AFB, California.[6,7,8,9] The civil aviation data were obtained from the National Transportation Safety Board (NTSB), Washington D.C.[4,10]

Table 1 summarizes total flying for the C-141 aircraft. None of this total is excluded since no significant amount of C-141 flying differs sufficiently from PNAF flying.

Table 2 summarizes total flying for the C-130 aircraft. Excluded flying is shown and deducted from the totals. Exclusions were made for flights conducted under conditions which differ significantly from PNAF flights. The large number of excluded accidents in the C-130 history of 60 destroyed

aircraft requires a substantial correction to the amount of flying. However, how much flying to exclude is not known and has to be estimated. This is because the flying history data for a type of aircraft is reported in a separate system from accident reports and is used primarily for different purposes. Thus, we cannot determine how much flying is associated, for instance, with low-level flight operations or with combat-zone operations where actual combat was taking place. So, we do not have a good basis for setting the correction.

An estimate is made by noting that the years 1966 through 1973 had the most departures per year, exceeding other years by about 70,000 departures each year. These years span the peak Vietnam war period, so the total correction for combat-related operations is estimated at 500,000 departures. The other excluded activities are estimated to account for 200,000 departures over the 18-year history of C-130 operations.

Figure 1 shows the categories used by the NTSB in tabulating data on U.S. air carriers. All of the tables of commercial aircraft accident data use these categories. The NTSB data are from References 4, 10, 11, and 12. Tables directly extracted from these references are so labeled. References 10 and 12 are directly included or condensed in the separate appendix.

The data on U.S. air carriers, used to compare to C-141 data, include all operations of certificated route carriers, supplemental carriers, and commercial operators of large aircraft that involved aircraft types similar to the C-141. The aircraft types included are shown in Table 3, along with their accident rates and total flying hours for the years 1968 through 1977. Table 3 only applies to certificated route carriers, but their operations account for 94% of the total flying hours by U.S. air carriers during 1977. The selected aircraft types shown account for 84.25% of the flying hours for certificated route carriers during the time period 1968 through 1977.

The accident rates in Table 4 come from detailed tabulation of commercial aircraft accidents shown in Table 7. The "All Accidents" category is defined more restrictively than the NTSB definition which counts accidents in which passenger injuries occur but the aircraft is undamaged.

Tables 5, 6, and 7 are summaries of the accidents considered in this study. Table 5 shows C-141 accidents; Table 6 shows C-130 accidents; and Table 7 shows the commercial aircraft accidents used in this study for comparison purposes. These tables summarize the circumstances of the accidents in four broad areas: accident class; cause of the accident; phase of flight in which the accident occurred; and categorization of the type of accident. The commercial accidents in Table 7 have a reduced list of causes and factors and are not categorized by accident type. A full list of definitions is provided in the "Keys to Accident Tables."

TABLE 1. C-141 TOTAL FLYING EXPOSURE BY YEAR

YEAR	HOURS FLOWN	NUMBER SORTIES	NUMBER DEPARTURES
65	35,367		37,450
66	189,240	39,794	122,007
67	461,772	96,082	194,333
68	672,627	163,439	244,166
69	642,291	208,654	253,917
70	612,518	147,265	251,790
71	487,929	125,318	235,288
72	471,440	121,151	213,995
73	362,532	97,014	181,814
74	286,377	78,500	177,351
75	314,771	85,134	169,149
76	281,622	77,981	155,365
77	299,191	83,461	171,598
78	282,594	81,205	170,983
TOTAL	5,400,277	1,404,998	2,577,256
			(2.08 Hr/Departure)

TABLE 2. C-130 TOTAL FLYING EXPOSURE BY YEAR

YEAR	HOURS FLOWN	NUMBER SORTIES	NUMBER DEPARTURES
65	554,237		313,325
66	730,887	242,761	469,245
67	659,861	283,436	448,183
68	594,058	334,372	445,338
69	537,126	350,559	436,509
70	504,113	241,335	422,852
71	487,137	185,962	430,005
72	480,989	155,418	413,695
73	399,605	131,720	374,987
74	360,549	117,736	371,934
75	365,181	151,764	383,740
76	336,592	124,444	323,726
77	334,524	126,973	335,040
78	348,168	144,420	364,841
TOTAL	6,693,047	2,590,900	5,533,420

Excluded (Combat-Related) - 500,000 Departures
Excluded (Other) - 200,000 Departures
PNAF Total - 4,800,000 Departures
(1.21 Hr/Departure)

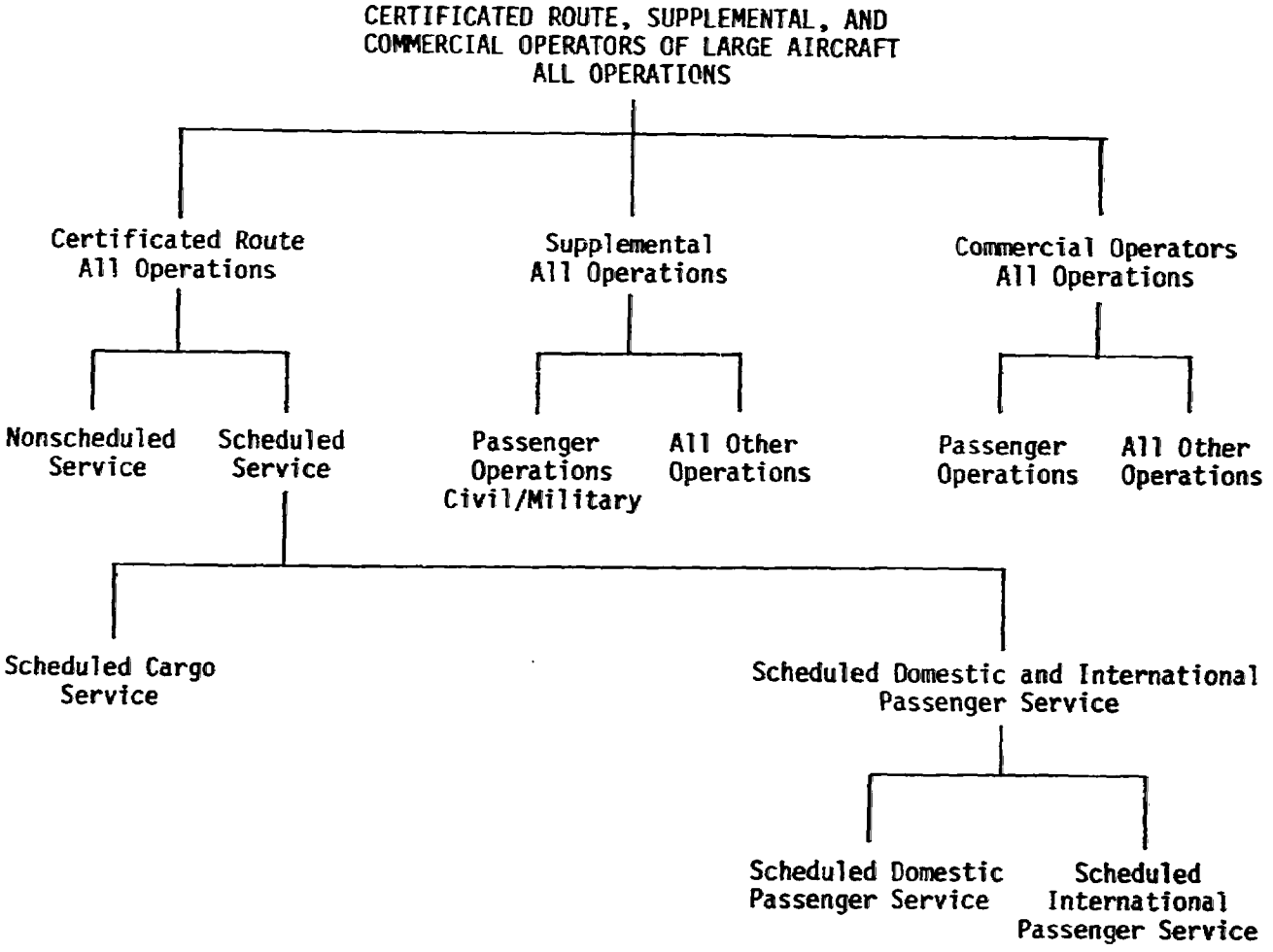

Figure 1. Classification and Type of Service, U.S. Air Carriers

TABLE 3. ACCIDENTS, RATES BY AIRCRAFT MAKE AND MODEL
U.S. CERTIFICATED ROUTE AIR CARRIERS, ALL OPERATIONS
1968 - 1978 (1978 PRELIMINARY)*

AIRCRAFT MAKE & MODEL	ACCIDENTS TOTAL	ACCIDENTS FATAL	AIRCRAFT HOURS FLOWN	ACCIDENT RATES PER 100,000 AIRCRAFT HOURS FLOWN TOTAL	ACCIDENT RATES PER 100,000 AIRCRAFT HOURS FLOWN FATAL
B-747	28	2	2,851,904	0.98	0.07
B-707 1/	67	14 2/	10,906,499	0.61	0.10
B-720	10	1	1,947,518	0.51	0.05
B-727	93	10	20,299,441	0.46	0.05
B-737	12	1	2,952,316	0.41	0.03
DC-8	56	5	6,296,514	0.89	0.08
DC-9	43	11 2/	9,409,311	0.46	0.10
DC-10	12	2	1,975,911	0.61	0.10
L-1011	12	2	1,052,458	1.14	0.19
CV-880	5	1	687,067	0.73	0.15
BAC-1-11	8	0	1,040,980	0.77	0.00
TOTAL	346	49	59,419,919	0.58	0.08

1/ A sabotage accident which occurred 8 September 1974 is included in all computations except rates.

2/ Includes midair collision accidents nonfatal to air carrier occupants, excluded in fatal accident rates.

Note: These makes and models of aircraft are the most widely used by certificated route air carriers, but this list does not contain the entire accident experience for this category of operations during the indicated years. The types shown flew a total of 53,595,612 hours from 1968 through 1977, while all types and models flew 63,597,427 hours in the same time period.

* Reference 4

TABLE 4. ACCIDENT RATES AND EXPOSURE FOR SELECTED AIRCRAFT TYPES, ALL OPERATIONS, ALL U.S. AIR CARRIERS

YEAR	HOURS FLOWN (THOUSANDS)	DEPARTURES HOUR	DEPARTURES (100,000)	ACCIDENTS ALL*	ACCIDENTS DESTROYED	RATE PER 100,000 DEPARTURES ALL*	RATE PER 100,000 DEPARTURES DESTROYED
1967	4945	1.0	49.5	12	5	.242	.101
1968	5395	.96	51.8	20	5	.386	.097
1969	5678	.91	51.7	27	4	.522	.077
1970	5451	.88	48.0	20	7	.417	.146
1971	5381	.88	47.4	19	4	.401	.084
1972	5309	.88	46.7	24	5	.514	.107
1973	5480	.87	47.7	19	5	.398	.105
1974	5036	.86	43.3	16	6	.370	.139
1975	5090	.87	44.3	16	2	.361	.045
1976	5247	.87	45.6	13	3	.285	.066
TOTAL	53,013		475.9	186	46	.391	.097

* Accidents having damage classified as "substantial" or more by the NTSB. This differs from the NTSB "All Accidents" rates which include injury-only type accidents that result in no damage to the aircraft.

Note: Accident occurrences taken from NTSB accident briefs[7] which are condensed in the appendix.

KEYS TO ACCIDENT TABLES

USAF Reports

Injury Classes

F - Fatal

Mj - Major (required hospitalization)

Mn - Minor

N - None

Damage Classes

D - Destroyed/Irreparably Damaged

Mj - Major

Mn - Minor

N - None

NTSB Reports

Injury Classes

F - Fatal

S - Serious

N - None/Minor

X/Y - For collisions with other aircraft, "X" is injuries aboard accident aircraft and "Y" is injuries aboard other aircraft.

Damage Classes

D - Destroyed

S - Substantial

M - Minor

N - None

All Reports

Causes/Factors. This includes the following categories of causes and contributing factors as discernible from the accident report:

Weather

Aircrew

Judgment: Aircrew used poor judgment and endangered the aircraft.

Wrong Action: Aircrew procedures were improper (misapplied controls, etc.).

Communication: Aircrew communication procedures were improper (failed to make a communication, used wrong communication procedure, missed hearing a communication, or misunderstood a communication).

Crew Rest: Aircrew violated crew rest rules.

Training: Aircrew was inadequately trained in an area significant to the accident.

Maintenance

Personnel Error: Poor maintenance.

Procedures/Data: Maintenance personnel followed standing rules, but the procedures or technical data were wrong or faulty.

Equipment, Test Gear: Faulty maintenance equipment contributed to the accident.

Airport, Airways, Facilities

Controller Error: Controller (including all ground personnel who issue instructions, clearances, and other information to the aircrew) made an error.

Communication: Same as for aircrew communication but applies to controllers.

Radar, Radio, etc: Ground electronic equipment failure contributed to the accident.

Ground Operations: Nonmaintenance ground activities contributed to the accident.

Aircraft Materiel Failure

Engine: Includes foreign object damage (FOD).

Instruments, Flight Controls: Self-explanatory.

Navigation, Communication, Radar: Electronic equipment failure.

Landing Gear, Brakes, Tires: Self-explanatory.

Power, Hydraulics: Electric or hydraulic power generation and distribution system failure.

Airframe and Control Surfaces: Includes spoiler, flaps, and cargo door failures.

Other (Self-explanatory)

Phase of Flight (Aircraft status when accident occurred)

Static, Ground Operations: Aircraft was parked or being towed. This includes parked and undergoing maintenance. Engines and/or power systems can be running.

Taxi: This includes taxiing on the ramp, taxiway, and crossing runways. It does not include extension of takeoff or landing roll.

Takeoff, Initial Climb: From start of takeoff roll until departure of airport vicinity with aircraft stabilized on departure heading, speed, and climb rate.

Prolonged Climb: From initial climb until cruise altitude.

In-flight Normal: Cruise flight, including altitude changes not associated with departure or arrival at destination.

Let-Down, Approach: Descent associated with arrival at destination through start of final approach.

Landing: Final approach through turn off of active runway.

Unknown: Damage was detected during postflight inspection, and time of occurrence cannot be determined.

First Type of Accident (If included, this section describes the initial occurrence of the accident.)

TABLE 5. C-141 ACCIDENTS

ACCIDENT NO.	INJURY CLASS	DAMAGE CLASS	CAUSES/FACTORS	PHASE OF FLIGHT	FIRST TYPE OF ACCIDENT
			Fatal Accidents (All Damage Classes)		
1	F	D	Maintenance (Procedures/Data, Equipment/Test Gear)	Static, Ground Ops	Other Aircraft Failure
2	F	D	Aircrew (Judgment, Communication)	Taxi	Collision with Aircraft (Ground)
3	F	D	Aircrew (Wrong Action)	Takeoff and Initial Climb	Collision with Ground
4	F	D	Aircrew (Wrong Action, Crew Rest), Airport/Airway/Fac (Communication)	Letdown, Approach	Collision with Ground
5	F	D	Aircrew (Communication, Training)	Letdown, Approach	Collision with Ground
6	F	D	Aircrew (Judgment, Crew Rest), Airport/Airway/Fac (Controller Error, Communication, Radar/Radio, etc.)	Letdown, Approach	Collision with Ground
7	F	D	Weather, Aircrew (Judgment), Acft Materiel Failure (Landing Gear/Brakes/Tires)	Letdown, Approach	Flew Into Weather Front/Storm
8	F	D	Aircrew (Judgment, Wrong Action, Crew Rest, Training)	Landing	Landing Short, Missed Go-Around
			Additional Accidents (Nonfatal, Aircraft Destroyed)		
9	N	D	Maintenance (Procedures/Data), Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Landing	Landing Gear Failure
			Additional Accidents (May Have Had Some Risk of Cargo Destruction)		
10	N	Mj	Aircraft Materiel Failure (Power/Hydraulics)	Static Ground Ops	Other Aircraft Failure
11	N	Mj	Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Static, Ground Ops	Landing Gear Failure
12	N	Mj	Maintenance (Procedures/Data), Aircraft Materiel Failure (Engine)	Takeoff and Initial Climb	Engine Failure/Damage (Other)
			Additional Accidents (Major Aircraft Damage)		
13	N	Mj	Maintenance (Personnel Error, Procedures/Data), Aircraft Materiel Failure (Cargo Door)	Prolonged Climb	Airframe Failure (Decomp, Ramp, Door)
14	N	Mj	Maintenance (Personnel Error, Procedures/Data), Aircraft Materiel Failure (Cargo Door)	Prolonged Climb	Airframe Failure (Decomp, Ramp, Door)
15	N	Mj	Maintenance (Personnel Error), Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Takeoff and Initial Climb	Landing Gear Failure
16	N	Mj	Aircraft Materiel Failure (Power/Hydraulics, Other)	Prolonged Climb	Airframe Failure (Other)
17	N	Mj	Maintenance (Personnel Error, Procedures/Data)	Landing	Landing Gear Failure
18	N	Mj	Maintenance (Personnel Error, Procedures/Data), Aircraft Materiel Failure (Cargo Door)	Inflight Normal	Airframe Failure (Decomp, Ramp, Door)
19	N	Mj	Maintenance (Personnel Error)	Taxi	Landing Gear Failure
20	N	Mj	Maintenance (Personnel Error, Procedures/Data)	Takeoff and Initial Climb	Engine Failure/Damage (Other)
21	N	Mj	Maintenance (Personnel Error, Procedures/Data)	Landing	Landing Gear Failure
22	Mj	Mj	Maintenance (Personnel Error, Procedures/Data)	Landing	Landing Gear Failure

TABLE 5 (Continued)

ACCIDENT NO.	INJURY CLASS	DAMAGE CLASS	CAUSES/FACTORS	PHASE OF FLIGHT	FIRST TYPE OF ACCIDENT
23	N	Mj	Aircrew (Wrong Action)	Taxi	Collision with Ground
24	N	Mj	Aircrew (Wrong Action)	Landing	Collision with Ground
			Additional Minor Accidents		
25	N	Mn	Weather, Aircrew (Judgment), Aircraft Materiel Failure (Nav/Com/Radar)	Prolonged Climb	Flew into Weather Front/Storm
26	N	Mn	Weather, Aircrew (Judgment), Airport/Airway/Fac (Controller Error, Communication, Radar/Radio/etc), Aircraft Materiel Failure (Nav/Com/Radar)	Prolonged Climb	Flew into Weather Front/Storm
27	N	Mn	Airframe/Control Surf (Cargo Door)	Inflight Normal	Airframe Failure (Decomp, Ramp, Door)
28	N	Mn	Aircrew (Wrong Action), Aircraft Materiel Failure (Airframe/Control Surf)	Letdown, Approach	Flew into Weather Front/Storm
29	N	Mn	Weather, Aircrew (Judgment), Airport/Airway/Fac (Communication)	Landing	Landing Short, Missed Go-Around
30	N	Mn	Aircrew (Judgment), Airport/Airway/Fac (Communication, Ground Ops)	Taxi	Collision with Vehicle, Building
31	N	Mn	Maintenance (Procedures/Data), Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Taxi	Landing Gear Failure
32	N	Mn	Maintenance (Procedures/Data), Airframe Control Surf (Spoilers/Flaps)	Unknown	Airframe Failure (Other)
33	N	Mn	Airport/Airway/Fac (Controller Error, Communication, Ground Ops)	Landing	Collision with Vehicle, Building
34	N	Mn	Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Static, Ground Ops	Landing Gear Failure
35	N	Mn	Maintenance (Procedures/Data, Equipment/Test Gear), Aircraft Materiel Failure (Inst/Flt Controls)	Inflight Normal	Engine Failure/Damage (FOD, Bird Strike), Other Aircraft Failure
36	N	Mn	Maintenance (Procedures/Data)	Static, Ground Ops	
37	N	Mn	Aircraft Materiel Failure (Engine)	Takeoff and Initial Climb	Engine Failure/Damage (FOD/Bird Strike)
38	N	Mn	Aircraft Materiel Failure (Engine)	Landing	Engine Failure/Damage (Other)
39	N	Mn	Overweight Taxi Test (Dev Testing, YC141B, Edwards AFB), Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Taxi	Landing Gear Failure
40	N	Mn	Aircraft Materiel Failure (Inst/Flt Controls), Airframe Control Surf (Spoilers/Flaps)	Landing	Hard Landing
41	N	Mn	Weather, Aircrew (Wrong Action), Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Landing	Hard Landing
42	N	Mn	Aircraft Materiel Failure (Engine)	Unknown	Engine Failure Damage (FOD/Bird Strike)
43	N	Mn	Maintenance (Personnel Error), Airframe Control Surf (Spoilers, Flaps)	Letdown, Approach	Airframe Failure (Other)
44	N	Mn	Aircraft Materiel Failure (Engine)	Unknown	Engine Failure Damage (FOD/Bird Strike)
45	N	Mn	Maintenance (Procedures/Data), Aircraft Materiel Failure (Engine)	Takeoff and Initial	Engine Failure/Damage (Other)
			Excluded Accidents		
46	N	Mn	Night Low-Level Training, Airdrop		
47	N	Mn	Red Flag (Low-Level)	Inflight Normal (Low (Low-Level)	Collision with Ground

TABLE 6. C-130 ACCIDENTS INVOLVING AIRCRAFT DESTRUCTION

ACCIDENT NO.	EXCLUDED ACCIDENT	INJURY CLASS	CAUSES/FACTORS	PHASE OF FLIGHT	FIRST TYPE OF ACCIDENT
1	X	F			
2		F	Weather, Aircrew (Judgment, Wrong Action)	Letdown, Approach	Collision with Ground
3		F	Aircraft Materiel Failure (Engine)	Takeoff and Initial Climb	Engine Failure/ Damage (Other)
4		Mj	Maintenance (Personnel Error)	Static, Ground Ops	Other Aircraft Failure
5		N	Aircrew (Judgment)	Taxi	Collision with Vehicle, Building
6	X	N			
7		N	Maintenance (Personnel Error)	Static, Ground Ops	Collision with Aircraft (Ground)
8	X	F			
9		F	Aircrew (Wrong Action, Training)	Landing	Collision with Ground
10		F	Weather, Aircrew (Judgment, Communication)	Landing	Collision with Ground
11		F	Aircrew (Judgment, Wrong Action), Aircraft Materiel Failure (Engine)	Takeoff and Initial Climb	Engine Failure/ Damage (Other)
12		F	Weather, Aircrew (Wrong Action)	Takeoff and Initial Climb	Collision with Ground
13	X	N			
14		F	Weather, Aircrew (Judgment, Wrong Action)	Letdown, Approach	Collision with Ground
15		F	Weather, Aircrew (Wrong Action)	Letdown, Approach	Collision with Ground
16		F	Aircrew (Wrong Action)	Inflight Normal	Collision with Ground
17	X	F			
18	X	N			
19		Mj	Maintenance (Procedures/Data), Aircraft Materiel Failure (Airframe/ Control Surf)	Takeoff and Initial Climb	Aircraft Failure (Other)
20	X	Mj			
21		F	Aircrew (Wrong Action, Crew Rest), Aircraft Materiel Failure (Landing Gear/Brakes/Tires)	Landing	Collision with Ground
22		F	Aircrew (Wrong Action), Aircraft Materiel Failure (Airframe/Control Surf)	Letdown, Approach	Collision with Ground
23		F	Aircrew (Judgment, Wrong Action, Crew Rest), Aircraft Materiel Failure (Engine)	Takeoff and Initial Climb	Engine Failure/ Damage (Other)
24	X	N			
25	X	F			
26	X	F			
27	X	F			
28	X	F			
29		N	Weather, Aircrew (Judgment, Wrong Action, Training)	Landing	Hard Landing
30	X	F			
31	X	N			
32	X	Mj			
33	X	N			
34	X	F			
35		F	Weather, Aircrew (Wrong Action, Communication), Airport/Airway/Fac (Communication)	Landing	Landing Short, Missed Go-Around
36	X	F			
37	X	F			
38		F	Aircraft Materiel Failure (Engine)	Takeoff and Initial Climb	Engine Failure/ Damage (Other)
39		F	Maintenance (Procedures/Data), Aircraft Materiel Failure (Landing Gear/ Brakes/Tires, Other)	Takeoff and Initial Climb	Other Aircraft Failure

Table 6 (Continued)

ACCIDENT NO.	EXCLUDED ACCIDENT	INJURY CLASS	CAUSES/FACTORS	PHASE OF FLIGHT	FIRST TYPE OF ACCIDENT
40	X	F			
41		F	Aircrew (Wrong Action, Communication)	Inflight Normal	Collision with Ground
42	X	F			
43		F	Airport/Airway/Fac (Communication)	Landing	Collision with Aircraft (Air)
44	X	F			
45	X	F			
46	X	F			
47	X	F			
48	X	F			
49		F	Aircrew (Wrong Action, Crew Rest, Training)	Takeoff and Initial Climb	Collision with Ground
50		Mj	Aircraft Materiel Failure (Inst/Flt Controls)	Letdown, Approach	Other Aircraft Failure
51	X	F			
52		F	Aircrew (Wrong Action), Aircraft Materiel Failure (Engine, Prop)	Takeoff and Initial Climb	Engine Failure/ Damage (Other)
53		F	Maintenance (Procedures/Data), Aircraft Materiel Failure (Engine, Prop)	Inflight Normal	Engine Failure/ Damage (Other)
			Class A* Accidents - 1977 & 1978		
54	X	F			
55		F	Aircrew (Wrong Action)	Landing	Collision with Ground
56		F	Aircrew (Wrong Action)	Landing	Collision with Ground
57	X	F			
58		N	Aircraft Materiel Failure (Engine)	Landing	Engine Failure/ Damage
59		F	Weather	Inflight Normal	Other Aircraft Failure
60		F	Aircraft Materiel Failure (Inst/Flt Controls)	Landing	Collision with Ground

* Accident definitions changed in 1977. Class A becomes most severe class.

TABLE 7. ACCIDENTS INVOLVING SELECTED AIRCRAFT TYPES, ALL U.S. CARRIERS, ALL OPERATIONS, 1967-1976

ACCIDENT NO.	DATE	AIRCRAFT TYPE	INJURY	DAMAGE	FACTORS	PHASE OF FLIGHT
1-0002	3/9/67	DC-9	F	D	Crew Error	Letdown
1-0004	6/23/67	BAC1-11	F	D	Maintenance/Materiel	Prolonged Climb
1-0005	7/19/67	B727	F	D	Controller Error	Prolonged Climb
1-0022	4/7/67	B727	N	S	Maintenance/Materiel	Landing
1-0026	4/29/67	B727	N	S	Weather	Landing
1-0027	6/24/67	CV880	N	S	Maintenance/Materiel	Prolonged Climb
1-0029	11/6/67	B707	F	D	Controller Comm	Takeoff
1-0033	11/20/67	CV880	F	D	Weather, Crew Judgment	Landing
1-0041	10/1/67	DC-8	N	S	Weather	Inflight
1-0049	8/25/67	DC-8	N	S	Weather	Inflight
1-0056	4/25/67	B707	N	S	Maintenance/Materiel	Landing
1-0068	9/9/67	B707	N	S	Maintenance/Materiel	Takeoff
1-0001	1/1/68	DC-8F	N	S	Weather, Crew Error	Taxi
1-0012	3/27/68	DC-9	N	S	Crew Error	Letdown
1-0021	6/12/68	B727	N	M	Crew Error	Letdown
1-0023	3/21/68	B727	S	D	Crew Error	Takeoff
1-0025	6/8/68	B727	N	S	Weather, Crew Error	Landing
1-0031	2/29/68	BAC1-11	N	S	Weather, Crew Error	Landing
1-0034	1/27/68	B707	N	S	Weather, Crew Error	Takeoff
1-0037	8/7/68	B727	N	S	Weather, Crew Error	
1-0039	12/27/68	DC-9	S	D	Weather, Crew Judgment	Takeoff
1-0045	12/26/68	B707	F	D	Crew Error	Takeoff
1-0047	11/19/68	B707	N	S	Maintenance/Materiel	Prolonged Climb
1-0048	3/23/68	DC-8	N	S	Maintenance/Materiel	Landing
1-0055	8/5/68	B707	N	S	Maintenance/Materiel	Landing
1-0056	9/6/68	B720	N	S		Static
1-0057	6/3/68	B727	N	S	Crew Error	Landing
1-0062	6/13/68	B707	F	D	Crew Error	Landing
1-0063	12/12/68	B707	F	D	Crew Error	Landing
1-0064	4/23/68	DC-8	N	S	Crew Error	Landing
1-0066	8/6/68	DC-8	S	S	Weather	Inflight
1-0069	6/12/68	DC-8	S	M	Weather, Crew Error	Inflight
1-0003	2/2/69	B707	N	S	Other	Static
1-0004	1/18/69	B727	F	D	Weather, Maintenance/ Materiel	Prolonged Climb
1-0006	5/14/69	B727	N	M	Crew Error	Static
1-0006-2	5/14/69	B727	N	S	Crew Error	Taxi
1-0007	2/9/69	B727	S	S	Maintenance/Materiel	Takeotf
1-0008	1/14/69	B727	N	S	Other	Static
1-0014	6/25/69	B727	S	S	Weather, Crew Judgment	Taxi
1-0016	9/9/69	DC-9	F	D	Controller Error	Letdown
1-0017	7/26/69	B707	F	D	Crew Error, Maintenance/Materiel	Landing
1-0018	4/27/69	DC-8	S	M	Weather, Crew Judgment	Inflight
1-0019	4/27/69	DC-8	S	M	Weather, Crew Judgment, Maintenance/Materiel	Inflight
1-0021	8/18/69	DC-9	N	M	Crew Judgment	Taxi
1-0025	7/20/69	DC-8	N	S	Weather, Crew Error	Landing
1-0028	1/31/69	DC-8	N	S	Maintenance/Materiel	Landing
1-0035	5/8/69	DC-8	N	S	Crew Error	Taxi
1-0044	7/29/69	B727	N	S	Crew Error	Takeoff
1-0046	8/12/69	DC-9	S	S	Weather, Crew Error	Landing
1-0050	11/20/69	DC-8	N	S	Crew Judgment	Taxi
1-0051	8/3/69	B707	N/F	S	Crew Error	Inflight
1-0052	2/6/69	DC-9	N/S	M	Crew Error	Landing
1-0054	11/28/69	DC-8	N	S	Maintenance/Materiel	Takeoff
1-0056	9/17/69	DC-8	N	S	Maintenance/Materiel	Takeoff
1-0058	10/16/69	DC-8	N	D	Maintenance/Materiel	Landing
1-0060	5/3/69	DC-9	N	S	Crew Error	Landing
1-0062	12/1/69	B707	N	S	Crew Error, Maintenance/Materiel	Takeoff
1-0063	8/1/69	B707	N	S	Crew Error	Landing
1-0001	11/4/70	B747	S	M	Weather	Prolonged Climb

TABLE 7 (Continued)

ACCIDENT NO.	DATE	AIRCRAFT TYPE	INJURY	DAMAGE	FACTORS	PHASE OF FLIGHT
1-0002	1/11/70	DC-9	N	S	Weather, Crew Error, Crew Communication	Landing
1-0010	7/27/70	DC-8	F	D	Weather, Crew Judgment	Landing
1-0010	9/8/70	DC-8F	F	D	Crew Judgment, Maintenance/Materiel	Takeoff
1-0012	7/19/70	B737	S	S	Crew Error, Maintenance/ Materiel	Takeoff
1-0013	4/20/70	DC-8	S	M	Weather	Inflight
1-0015	6/3/70	B727	N	S	Maintenance/Materiel	Static
1-0016	9/8/70	DC-9	N	S	Crew Error	Landing
1-0023	11/14/70	DC-9	F	D	Crew Error	Letdown
1-0025	11/27/70	DC-8	F	D	Weather, Maintenance/ Materiel	Takeoff
1-0026	12/28/70	B727	F	D	Crew Error	Landing
1-0029	6/9/70	DC-8F	S	M	Maintenance/Materiel	Takeoff
1-0034	9/21/70	DC-8	S	M	Weather	Letdown
1-0037	9/18/70	B707	S	M	Weather	Inflight
1-0040	11/4/70	B727	N	S	Maintenance/Materiel	Taxi
1-0047	12/16/70	B727	N	S	Maintenance/Materiel	Landing
1-0053	9/29/70	B720	N	S	Crew Error	Landing
1-0054	11/30/70	B707	N/F	D	Crew Error, Crew Comm, Controller Error, Controller Comm	Takeoff
1-0055	3/28/70	B720	N	S	Maintenance/Materiel	Prolonged Climb
1-0001	1/9/71	B707	N/F	S	Crew Error, Controller Error	Inflight
1-0002	3/31/71	B720	F	D	Weather, Maintenance/ Materiel	Landing
1-0003	2/17/71	DC-9	N	S	Weather, Crew Error	Landing
1-0004	1/11/71	DC-9	N	S	Weather, Crew Error	Landing
1-0005	6/6/71	DC-9	F	D	Crew Error, Controller Error	Prolonged Climb
1-0007	7/30/71	B747	N	S	Crew Error, Other	Takeoff
1-0008	9/4/71	B727	F	D	Weather, Crew Error, Maintenance/Materiel	Landing
1-0014	8/4/71	B707	N/S	S	Crew Error	Letdown
1-0015	7/1?/71	B727	N	S	Crew Error	
1-0017	7/23/71	B747		M	Maintenance/Materiel	Taxi
1-0021	12/4/71	DC-9	F	M	Controller Error	Landing
1-0025	7/25/71	B707	F	D	Crew Error	Landing
1-0027	2/7/71	B747	S	M	Weather	Inflight
1-0031	2/26/71	B727	N	S	Maintenance/Materiel	Landing
1-0036	8/18/71	DC-9	N	S	Other	Prolonged Climb
1-0038	5/22/71	DC-9	N	S	Maintenance/Materiel	Prolonged Climb
1-0039	6/20/71	B747	N	S	Other	Takeoff
1-0043	8/14/71	DC-8	N	S	Other	Takeoff
1-0047	11/17/71	B727	N	S	Maintenance/Materiel	Prolonged Climb
1-0002	5/18/72	DC-9	S	D	Weather, Crew Comm	Landing
1-0003	5/30/72	DC-9	F	D	Other	Landing
1-0004	6/12/72	DC-10	N	S	Maintenance/Materiel, Other	Prolonged Climb
1-0006	1/4/72	B747	S	M	Weather, Crew Error	Inflight
1-0011	3/19/72	DC-9	N	S	Maintenance/Materiel	Takeoff
1-0013	9/1/72	B747	S	M	Crew Error, Maintenance/Materiel, Controller Comm	Taxi
1-0016	12/29/72	L1011	F	D	Crew Error, Maintenance/Materiel	Letdown
1-0017	12/20/72	CV880	N	S	Weather, Crew Error, Crew Comm, Controller Error	Taxi
1-0017A	12/20/72	DC-9	F	D	Weather, Controller Error	Takeoff
1-0018	5/10/72	DC-9	N	S	Maintenance/Materiel	Static
1-0022	9/13/72	B707	N	S	Maintenance/Materiel	Takeoff
1-0027	7/18/72	B707	S	N	Maintenance/Materiel, Other	Inflight
1-0031	9/30/72	B727	S	M	Weather, Crew Judgment	Inflight
1-0034	6/14/72	DC-9	N	S	Crew Judgment	Landing
1-0035	9/28/72	DC-9	N	S	Crew Error	Landing
1-0037	12/15/72	B747	N	S	Weather, Maintenance/ Materiel, Other	Takeoff
1-0038	11/1/72	B707	S	M	Maintenance/Materiel	Landing
1-0040	11/8/72	B727	N	S	Maintenance/Materiel	Taxi
1-0041	10/1/72	B727	N	S	Maintenance/Materiel	Landing
1-0045	12/28/72	L1011	N	S	Maintenance/Materiel	Inflight

TABLE 7 (Continued)

ACCIDENT NO.	DATE	AIRCRAFT TYPE	INJURY	DAMAGE	FACTORS	PHASE OF FLIGHT
1-0046	10/30/72	B727	N	S	Maintenance/Materiel	Taxi
1-0048	12/8/72	B737	F	D	Crew Error	Landing
1-0049	6/10/72	B727	S	M	Other	Static
1-0050	3/8/72	B747	N	S	Crew Error	Taxi
1-0001	1/20/73	B707	N	S	Maintenance/Materiel	Prolonged Climb
1-0003	1/12/73	L1011	N	S	Crew Error	Landing
1-0005	3/3/73	B727	N	S	Weather, Crew Error	Landing
1-0009	3/5/73	B707	N	S	Crew Error	Takeoff
1-0010	4/9/73	B707	N	S	Maintenance/Materiel	Taxi
1-0011	7/31/73	DC-9	F	D	Weather, Crew Error	Landing
1-0015	6/2/73	DC-8	S	M	Maintenance/Materiel	Takeoff
1-0018	9/8/73	DC-8	F	D	Weather, Crew Error	Letdown
1-0019	10/28/73	B737	N	S	Crew Error	Landing
1-0025	8/22/73	B737	N	N	Maintenance/Materiel	Inflight
1-0026	11/3/73	B707	F	D	Crew Error	Landing
1-0028	11/27/73	DC-9	S	D	Weather, Crew Error	Landing
1-0029	11/27/73	DC-9	S	S	Weather, Crew Error	Landing
1-0033	12/9/73	B727	N	S	Crew Error	Taxi
1-0035	12/17/73	DC-9	N	S	Weather, Crew Judgment Crew Error, Maintenance/ Materiel	Takeoff
1-0038	7/22/73	B707	F	D	Other	Takeoff
1-0039	8/8/73	B727	N	S	Maintenance/Materiel	Takeoff
1-0042	8/28/73	B707	F	N	Other	Letdown
1-0043	11/3/73	DC-10	F	S	Maintenance/Materiel	Inflight
1-0001	1/30/74	B707	F	D	Weather, Crew Error	Landing
1-0002	1/4/74	B727	S	M	Maintenance/Materiel	Takeoff
1-0011	1/1/74	B707	N	M	Crew Error, Controller Error, Controller Comm	Taxi
1-0012	1/16/74	B707	S	D	Weather, Crew Error	Landing
1-0013	7/8/74	DC-10	N	S	Maintenance/Materiel	Prolonged Climb
1-0014	1/17/74	B707	N	S	Weather, Crew Error, Controller Error, Controller Comm	Landing
1-0019	3/27/74	DC-8	S	M	Maintenance/Materiel	Takeoff
1-0020	9/11/74	DC-9	F	D	Crew Error	Landing
1-0023	7/3/74	L1011	S	N	Weather, Crew Judgment	Landing
1-0029	12/1/74	B727	F	D	Weather, Crew Judgment, Controller Comm	Landing
1-0031	12/1/74	B727	F	D	Weather, Crew Error	Prolonged Climb
1-0037	11/21/74	B747	N	N	Crew Judgment	Taxi
1-0037A	11/21/74	DC-9	N	S	Other	Taxi
1-0038	11/25/74	B727	N	S	Other	Static
1-0046	11/25/74	B707	S	M	Maintenance/Materiel	Static
1-0047	4/22/74	B707	F	D	Crew Error	Landing
1-0001	3/31/75	B737	S	S	Weather, Crew Judgment	Landing
1-0002	2/4/75	B727	N	S	Maintenance/Materiel	Static
1-0003	2/18/75	B707	N	S	Maintenance/Materiel	Landing
1-0006	6/24/75	B727	F	D	Weather, Crew Judgment, Controller Error	Landing
1-0012	8/7/75	B727	S	S	Weather	Takeoff
1-0019	6/14/75	L1011	S	N	Maintenance/Materiel	Static
1-0021	11/12/75	DC-10	S	D	Maintenance/Materiel, Other	Takeoff
1-0021	11/12/75	B727	S	S	Weather, Crew Error	Landing
1-0026	9/8/75	B747	N	S	Maintenance/Materiel	Landing
1-0027	8/23/75	B727	N	S	Maintenance/Materiel	Landing
1-0029	8/16/75	B727	N	S	Crew Judgment, Maintenance/Materiel	Taxi
1-0032	8/25/75	DC-10	N	S	Maintenance/Materiel	Takeoff
1-0037	10/16/75	DC-10	S	N	Maintenance/Materiel	Taxi
1-0038	12/22/75	DC-8	N	S	Weather, Crew Judgment	Taxi
1-0041	9/20/75	DC-8	N	S	Weather, Crew Judgment	Takeoff
1-0044	12/22/75	B707	S	S	Crew Error	Landing
1-0002	1/17/76	B727	S	M	Other	Static
1-0003	4/5/76	B727	F	D	Weather, Crew Error	Landing
1-0005	4/27/76	B727	F	D	Crew Judgment, Crew Error	Landing
1-0006	5/6/76	B747	N	S	Crew Error	Landing
1-0009	6/1/76	L1011	N	S	Maintenance/Materiel	Letdown
1-0010	5/27/76	DC-10	N	S	Crew Error	Taxi
1-0011	6/23/76	DC-9	S	D	Weather, Controller Comm	Landing
1-0012	2/16/76	B727	S	S	Maintenance/Materiel	Takeoff
1-0020	11/16/76	DC-9	S	S	Other	Takeoff
1-0022	11/12/76	DC-9	N	S	Crew Error	Taxi
1-0024	1/2/76	DC-10	S	S	Other	Landing
1-0026	8/4/76	B727	N	S	Maintenance/Materiel	Landing
1-0028	4/24/76	B707	N	S	Other	Taxi

ACCIDENT RATES

Total accidents and exposure for C-130, C-141, and commercial aircraft similar to the C-141 are shown in Table 8.

The resulting rates are shown in Table 9 and apply fleet-wide to the aircraft types shown. Exclusions have been made only for accidents occurring during missions completely unlike PNAF missions. No corrections have been made for pilot selection, maintenance controls, or restrictive conditions of flight. The 90% and 98% confidence intervals are taken from Molina's tables[13] by interpolation. The 90% interval is found by taking the interval between the values: "what (high) value of frequency of occurrence would cause the observed number of accidents or fewer to occur in this number of departures only 5% of the time," and "what (low) value of frequency of occurrence would cause the observed number of accidents or more to occur in this number of departures only 5% of the time." The 98% interval is similarly defined, except that 1% is used rather than 5%. The assumption made in determining these intervals is that the Poisson distribution function is applicable—in this case, a very good assumption. No further approximations are made as the intervals come from tables of the actual integral distribution function.

Tables 10 and 11 show accident rates by cause or contributing factor and by phase of flight. They are taken directly from Tables 5, 6, and 7. Table 12 shows causes and factors from the NTSB annual report (Reference 4) and is shown for comparison.

The phase-of-flight tabulations in Table 10 show that negligibly few accidents that destroy aircraft (of the type considered in this study) occur during the "inflight-normal cruise" phase of flight. Virtually all such accidents occur during takeoff or during letdown and landing, with about twice as many occurring in the landing phase as in the takeoff phase. For this reason, it is inappropriate for this study to give accident rates

for destroyed aircraft in terms of hours or miles of flight. The preferred method is to use departures.

Table 11 shows which causes and contributing factors are associated with accidents that resulted in destroyed aircraft. Although the meaning of this table is somewhat obscure, it does contain useful information. First of all, note that the table does not apply to normal day-to-day flight conditions. It applies to literally one in a million accidents. Also, it does not indicate how frequently the accidents occur, only what events were associated with the accidents when they did occur. An example may help. It is interesting that in accidents that destroyed commercial aircraft, aircrew errors in judgment or actions were involved in a little over half of the accidents. This is also true for destroyed C-141 aircraft, but the accident rates show that the C-141 accidents occur nearly four times more frequently. Therefore, Table 11 shows that, when an accident situation occurred, the military pilots and the civilian pilots had made the same kind of lapses and errors that led to that accident situation. When we also look at the frequency of accidents (if we simplistically place all accident blame on pilots), we would conclude that the military pilots made these same kind of errors four times more frequently. Therefore, the purpose of Table 11 is to characterize the accident, not to describe accident rates. Differences appearing in this table show differences in the circumstances of the accident.

Table 12 shows the percentage distributions of causes or related factors for commercial aircraft accidents. For the 10-year period (1968 through 1977), weather was the most frequently cited cause/factor in U.S. certificated route air carrier accidents, followed by personnel and the pilot. The pilot, followed by weather and personnel, was the most frequently cited cause/factor in fatal accidents.

TABLE 8. AIRCRAFT DESTROYED (C-130, C-141, COMMERCIAL)

AIRCRAFT	DEPARTURES	AIRCRAFT DESTROYED
C-130	4,833,000	27 (1965-1978)
C-141	2,577,000	9
Commercial	47,590,000	45

Note: The rates and confidence limits are shown in Table 9.

TABLE 9. ACCIDENT RATES FOR ACCIDENTS RESULTING IN DESTRUCTION OF THE AIRCRAFT (PER 1,000,000 DEPARTURES)

AIRCRAFT	98% (LOW)	90% (LOW)	MEAN	90% (HI)	98% (HI)
C-130	4.23	4.65	5.59	8.62	9.62
C-141	1.39	1.82	3.49	6.09	7.30
Commercial	.67	.74	.97	1.24	1.35

Note: These rates are "overall rates" not "PNAF rates"—see text for explanation of confidence intervals.

TABLE 10. AIRCRAFT ACCIDENTS BY PHASE OF FLIGHT

	C-141 ACFT DEST		C-130 ACFT DEST		COMMERCIAL* ACFT DEST		C-141 ALL		COMMERCIAL* ALL**	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
Static	1	11.1	2	6.5	0	0.0	5	10.9	12	6.5
Taxi	1	11.1	1	3.2	0	0.0	6	8.7	24	12.9
Takeoff	1	11.1	9	20.0	11	23.9	6	13.0	36	19.4
Prolonged Climb	0	0.0	0	0.0	5	10.9	5	10.9	15	8.1
Inflight (Cruise)	0	0.0	4	12.9	0	0.0	3	6.5	17	9.1
Let Down	4	44.4	5	16.1	5	10.9	6	13.0	12	6.5
Landing	2	22.2	10	32.3	25	54.3	11	21.7	67	36.0
Unknown	-	-	-	-	-	-	3	10.9	-	-

* Selected Aircraft Types, All U.S. Air Carriers, All Operations.
** Does not include accidents resulting in passenger injuries without aircraft damage.

TABLE 11. ACCIDENTS BY CAUSE/CONTRIBUTING FACTORS

CAUSE/ CONTRIBUTING FACTOR	C-141 ACFT DEST NO.	C-141 ACFT DEST %	C-130 ACFT DEST NO.	C-130 ACFT DEST %	COMMERCIAL ACFT DEST NO.	COMMERCIAL ACFT DEST %	C-141 ALL NO.	C-141 ALL %	COMMERCIAL ALL NO.	COMMERCIAL ALL %
Weather	1	11.1	8	25.8	19	41.3	5	10.9	56	30.1
Aircrew: Judgment	4	44.4	7	22.6	7	15.2	8	17.4	21	11.3
Wrong Action	3	33.3	17	54.8	26	56.5	5	10.9	76	40.9
Communication	2	22.2	3	9.7	-	-	2	4.3	-	-
Crew Rest	3	33.3	3	9.7	-	-	3	6.5	-	-
Training	2	22.2	3	9.7	-	-	3	6.5	-	-
Maintenance or Aircraft Failure	3	33.3	15	48.4	9	19.6	32	69.6	68	36.6
Maintenance	2	22.2	5	16.1	-	-	18	39.1	-	-
Acft Failure	2	22.2	12	38.7	-	-	28	60.9	-	-
Airport/Airways/Ground Operations/Other	3	33.3	2	6.5	12	26.1	14	30.4	36	19.4
(Total No. of Accidents)	(9)		(31)		(46)		(45)		(186)	

Note: The percentage totals exceed 100% because multiple causes/factors can be cited in any accident.

TABLE 12. CAUSES/FACTORS—CERTIFICATED ROUTE AIR CARRIERS, 1968 THROUGH 1977, FROM NTSB REPORT*

CAUSES/FACTORS	PERCENTAGE OF TOTAL ACCIDENTS	PERCENTAGE OF FATAL ACCIDENTS
Weather	48.3	45.3
Personnel	46.6	42.2
Pilot	39.5	62.5
Airport/Airways/Facilities	9.0	4.7
Landing Gear	8.8	3.1
Power Plant	7.3	4.7
Systems	6.6	9.4
Miscellaneous	6.3	12.5
Instruments/Equipment	2.7	3.1
Airframe	2.4	6.2
Terrain	1.7	0.0
Undetermined	1.2	6.2
Rotorcraft	0.7	3.1

Note: The percentage totals exceed 100% because multiple causes/factors can be cited in any accident.

* Reference 4

CONCLUSIONS

PNAF C-141 Accident Rate

The accident rate for all C-141 accidents is three and one-half per million departures.

The commercial accident rate for aircraft types similar to the C-141 is one per million departures.

PNAF differs from all C-141 aircraft in areas of crew selection and maintenance, but it is not greatly different in conditions of flight. PNAF differs from commercial flights in conditions of flight, but it is assumed to be similar in terms of crew selection and maintenance.

The character of accidents that destroyed C-141 aircraft (non-PNAF) and similar commercial aircraft shows that commercial accidents involved weather about four times more frequently and involved maintenance or materiel failure about half as frequently.

These differences are interrelated and are not separable because they are not due to independent causes.

If PNAF crew selection and maintenance were equal to the commercial population, the difference in conditions of flight would make the PNAF accident rate lower than one per million departures.

As a conservative high estimate, the PNAF accident rate is judged to be one destroyed aircraft per million departures.

This estimated rate could easily be in error by as much as a factor of two; however, for this type of problem, a factor of two uncertainty is not especially significant.

C-130 Accident Rate

The C-130 accident rate for the whole fleet, considering all flying and accidents that are not completely unlike PNAF flying, is about five and one-half destroyed aircraft per million departures.

Materiel failure seems to be a more significant factor in C-130 crashes than for the other aircraft considered in this study. Thus, the special maintenance practices for PNAF have a potentially greater effect.

The accident rate for PNAF C-130 missions is estimated to be less than two destroyed aircraft per million departures.

Use of C-130 Aircraft

Whenever short runways and other adverse field conditions exist, it is safer to use C-130 aircraft to carry nuclear weapons to and from such fields than it is to use C-141 aircraft because of the C-130's ability to operate from smaller airfields.

C-130 and C-141 accident rates are not greatly different. In fact, it is not possible to state with high statistical confidence that they are different at all.

PNAF Practices/Important Factors

Crew selection for skill and maturity is important.

Special maintenance practices and controls are probably valuable. They are probably most important as applied to the C-130.

Avoidance of adverse weather is important, especially on landings.

All these practices, taken together, probably cause the PNAF accident rate to be half an order of magnitude lower than the fleet average. They may have as great an effect as a full order of magnitude reduction.

Accident Reporting

The USAF accident reporting system does an excellent job of reporting the circumstances of accidents. The use of this accident data is severely limited by the extremely poor reporting of flying data from which exposure can be determined.

REFERENCES

1. Accident Environments Expected in Air Force C-5, C-141, and C-130 Aircraft Accidents, SAND 75-0231, Clarke, Foley, Hartman, and Larson, August 1979. (FOUO)

2. Severities of Transportation Accidents, SLA-74-0001, Clarke, Foley, Hartman, and Larson, July 1976.

3. Forward Look, Final Report, Safety and Security Risk Analysis of DOD Peacetime Nuclear Weapon Transportation, Vol 39, SAND 79-1441, Ling, W. H., July 1979. (Secret-FRD)

4. Annual Review of Aircraft Accident Data, U.S. Air Carrier Operations, 1977, NTSB-ARC-78-2, National Transportation Safety Board, 6 September 1978.

5. Accidents, Rates by Aircraft Make and Model, U.S. Certificated Route Air Carriers, All Operations, 1968-1978, National Transportation Safety Board, 20 June 1979.

6. Major Accidents, 1962 to Date, in C-130 Aircraft When Aircraft Was Destroyed, Air Force Inspection and Safety Center, 1976. (Privileged Report, AFR 127-4, Not Releasable Outside the Air Force)

7. C-141 Accidents, 1967 to Date, When Aircraft Was Destroyed, Air Force Inspection and Safety Center, 15 January 1977. (Privileged Report, AFR 127-4, Not Releasable Outside the Air Force)

8. C-141 Class A and B Accidents in 1966 and 1967, Air Force Inspection and Safety Center, 12 October 1979. (Privileged Report, AFR 127-4, Not Releasable Outside the Air Force)

9. C-141 Class A and B Accidents, 1968 to Date, Air Force Inspection and Safety Center, 12 October 1979. (Privileged Report, AFR 127-4, Not Releasable Outside the Air Force)

10. Briefs of Accidents Involving Turbojet/Turbofan Aircraft, U.S. Air Carriers, 1967-1978, National Transportation Safety Board, October 1979.

11. Special Study: Flightcrew Coordination Procedures in Air Carrier Instrument Landing System Approach Accidents, NTSB-AAS-76-5, National Transportation Safety Board, 18 August 1976.

12. Briefs of U.S. Air Carriers, All Operations, 1967 through 1974, National Transportation Safety Board, July 1980.

13. Poisson's Exponential Binomial Limit, Molina, E. C., VanNostrand, D., 1942.

14. MACR 55-18, Vol. I (C-1), "Nuclear Airlift Operations," 19 June 1979.

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